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PACIFIC NORTHWEST
U. S. FOREST SERVICE
Research Note
FOREST AND RANGE EXPERIMENT STATION · U.S. DEPARTMENT OF AGRICULTURE · PORTLAND, OREGON

PNW-42
September 1966

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COMPATIBILITY OF BALLOON FABRICS WITH AMMONIA

by

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Our recent logging test of a single-hull balloon[1] identified a major problem in connection with the high cost of inflation gas. Helium, the currently preferred gas, is not only inherently costly to produce, it is also expensive to transport and store in high-pressure containers.

Previous efforts to reduce the cost of balloon inflation through the use of hydrogen met with little acceptance due to its explosive properties under a wide range of air mixtures. Other efforts to reduce cost by using ammonia were limited to expendable balloons where good fabric life and high static lift were relatively unimportant.

Previous research[2] has determined that a balloon's static lift is only one of several forces available that may be combined to lift and move the logs. Therefore, even though ammonia provides slightly less than half the gross static lift of helium, it merits careful consideration for a possible application in balloon logging.

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[1] Lysons, Hilton H., Binkley, Virgil W., and Mann, Charles N. Logging test of a single-hull balloon. U.S. Forest Serv. Res. Pap. PNW-30, 20 pp., illus. 1966.

[2] Mann, Charles N. Forces in balloon logging. U.S. Forest Serv. Res. Note PNW-28, 5 pp., illus. 1965.

A brief review of the properties of ammonia[3] showed that, although it can be made to explode when mixed with air, there is little likelihood of this occurring out-of-doors due to its very narrow explosive mixture range. Ammonia also presents certain toxic hazards, but its widespread use indicates that it can be safely handled by established procedures.

The two major advantages of ammonia for balloon inflation are:

1. It is very inexpensive when compared with helium.
2. It is readily transported in liquid form from widely available sources (1 ton of anhydrous ammonia produces 45,000 cubic feet of gas).[4]

Two important unknowns exist in connection with using ammonia in logging balloons:

1. Will it provide an adequate amount of static lift in a suitable logging balloon configuration?
2. Will it be compatible with present or future balloon fabrics?

Since the first question cannot be answered without specifying the balloon's fabric and weight, the second question was investigated. By Contract No. 19-50, the Pacific Northwest Forest and Range Experiment Station requested the GCA Viron Division, GCA Corporation, in Minneapolis, Minn., to determine the compatibility of representative balloon fabrics with ammonia.

This test, conducted under the direction of James A. Menke, project manager, GCA Viron Division, was completed in February 1966. The final report[5] is on file at this Station and is available to interested logging balloon designers and users.

The following information has been extracted from GCA Viron's final report to cover the most pertinent results.

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[3] Manufacturers Chemists' Association, Inc. Properties and essential information for safe handling and use of anhydrous ammonia. Chemical Safety Data Sheet SD-8, 16 pp., illus. 1952.

[4] Compressed Gas Association, Inc. Anhydrous ammonia. Pamphlet G-2, 33 pp., illus. 1956.

[5] Menke, James A., and Ruffenbach, Gene. Compatibility of balloon fabrics with ammonia. Prepared by GCA Viron Division, GCA Corp., for Pacific Northwest Forest and Range Exp. Sta., Forest Serv., U.S. Dep. Agr., Portland, Oreg., 19 pp., illus. 1966.

I. OBJECTIVE

The objective of this program was to determine the compatibility of representative balloon materials with ammonia. Use of ammonia as a balloon inflatant is attractive because of its low cost, availability, and compressiblity. Anhydrous ammonia and ammonia in combination with water will react with many organic functional groups. As such, most organic polymers will degrade on exposure to ammonia. Selected fabrics were exposed to anhydrous ammonia (NH_3) and ammonium hydroxide (NH_4OH) at a temperature of 125° F. for 8 weeks. Physical properties of the fabrics were determined before, during, and after exposure.

II. TEST EQUIPMENT

A. Environmental chambers

Five transparent inflatable chambers were used to contain the sample materials. Samples were hung from the top or submerged in trays of water on the bottom of the chambers. Inflatable rather than rigid containers were used to visually indicate ammonia leakage or absorption in water and thereby facilitate maintenance of a high ammonia concentration. Each chamber had an inflation tube extending outside the oven for refilling. Figure 1 shows the environmental test setup.

B. Oven

The five containers were placed in a large oven and held at 125° F. Because ammonia is explosive (at a concentration of 16 to 25 percent with air), the electric heat source was placed outside the oven and an open forced-air system was used. The temperature of the oven was controlled by a thermostat. The temperature was also monitored by a Brown Recorder to check temperature range and stability.

C. Material testing equipment

1. A floor model TTC Instron was used to measure tensile strength (accuracy, 1 percent of full scale).
2. A Cambridge fabric permeameter was used to measure helium permeability (accuracy, 3 percent of full scale).
3. A Mettler Analytic Balance was used to measure change in weight (accuracy, $\pm$ 0.001 g.).

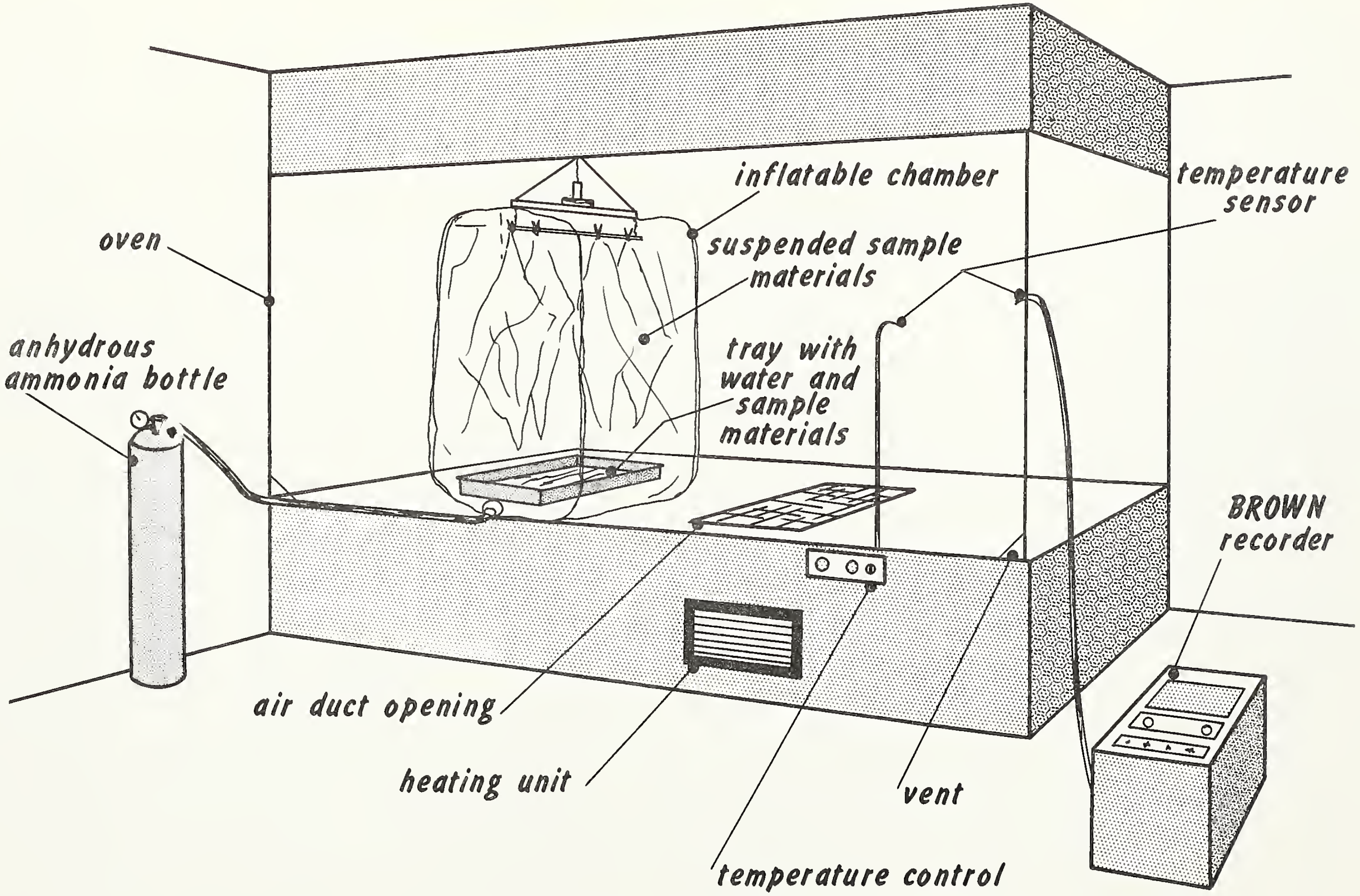

Figure 1.--Setup for testing compatibility of balloon fabrics with ammonia.

III. SELECTED MATERIALS AND ADHESIVES

Eleven representative balloon materials and three seam adhesives were tested. A description of these materials is in tables 1 and 2.

Table 1.--Selected materials

Material identification number	Base fabric	Base fabric weight per square yard	Coating, side 1	Coating, side 2	Material weight per square yard
		Ounces			Ounces
1	Nylon	3.8	Urethane	Urethane	6.5
3	Nylon	5.1	Neoprene	Urethane	15.2
4	Nylon	5.1	Urethane	Uncoated	10.5
5	Nylon	5.1	Hypalon	Hypalon	19.5
6	Nylon	4.3	Urethane	Urethane	7.4
7	Nylon	3.85	Uncoated	Uncoated	3.85
8	Dacron	4.25	Uncoated	Uncoated	4.25
11	Nylon	6.4	Vinyl	Vinyl	21.0
12	Dacron	8.0	Hypalon	Hypalon	24.0
14	Glass cloth	3.1	Uncoated	Uncoated	3.1
18	Nylon	5.1	Neoprene	Neoprene	16.0

Table 2.--Selected seam adhesives

Material number	Adhesive
1, 4	Bostik 7074A and B
3	Caram 244
5, 11, 12	Fairprene 5149

Adhesives were selected for test on the basis of past experience and reliability. The seams were made by the cleaning, sanding, and coating methods described in the adhesive manufacturer's recommended procedure.

IV. TEST PROCEDURE

A. Material properties tests

The physical property tests to determine deterioration were conducted in accordance with the following test standards:

		CCC-T-191 b[1]	ASTM method[2]
1.	Strength and elongation, breaking of woven cloth; cut strip method	5102.1	--
2.	Tear strength of cloth, tongue method	5134.1	--
3.	Helium permeability of rubber-coated fabrics	--	D815-47
4.	Peel or stripping strength of adhesives	--	D903-49
5.	Adhesion of lapped seam	5102	--
6.	Weight of cloth; small specimen method	5041	--

[1] This is a Federal specification.

[2] American Society for Testing Materials.

The above tests were conducted on the fabrics both before and after the 8-week period. Tests 1, 3, and 5 were also run at 2-week intervals. Tests 2, 4, and 6 were run at the beginning of the test period and after 8 weeks' exposure.

B. Environment tests

Sample materials were placed in five sealed containers. Half the samples in each container were suspended from the top (NH_3 gas) with the remaining samples submerged in the water (NH_4OH). The water absorbed a large amount of NH_3; thus, the bags were refilled with ammonia until the water was saturated. The solubility of NH_3 in water is approximately 760 to 1 by volume. Each chamber had a temperature of 125° F. with a relative humidity of 100 percent (due to the tray of water). At 2-week intervals, samples of each material were removed from the container and the container resealed.

V. TEST RESULTS

A complete tabulation of test results is available, on request, to interested readers wishing additional information on any of the following materials:

Material No. 1

Tests were discontinued after 4 weeks because the urethane coating failed in both the NH_3 and NH_4OH environment. The urethane became brittle and cracked. It also powdered and began to fall off as shown by the weight loss. The Bostik 7074A and B adhesive became powdery almost instantly.

Material No. 3

The neoprene side survived but the urethane side was destroyed. The urethane side was brittle and cracked when folded. The deterioration affected only the urethane and not the neoprene or nylon. The Caram 244 adhesive was applied to the neoprene side only. Failure of the seams in the ammonium hydroxide was an adhesive failure. The Caram 244 became powdery after 8 weeks' immersion in NH_4OH.

Material No. 4

Tests were discontinued because the urethane coating failed. It became brittle and cracked. The Bostik 7074A and B seams separated during the first 2 weeks. The nylon was not affected.

Material No. 5

Tests were discontinued due to the failure of the hypalon coating. The white hypalon turned brown. This material absorbed a very large amount of water. The hypalon became very soft and it peeled off the nylon easily. The Fairprene 5149 adhesive turned brown in NH_3 but retained fairly significant strength. In NH_4OH the Fairprene 5149 became powdery.

Material No. 6

Tests were discontinued because the urethane coating failed. The coating began to fall off (in a powder form) during the first 2 weeks. This was shown by the weight loss.

Material No. 7

No deterioration was seen on the nylon fabric. It did become slightly stiffer after the test. (This stiffness could have been due to the presence of dissolved residues of the other samples in the NH_4OH.)

Material No. 8

The dacron was removed from test because it turned from white to brown and disintegrated.

Material No. 11

The yellow vinyl coating turned white. The vinyl became sticky to the touch and the permeability (leak rate) increased greatly. The point of seam failure could not be determined because the vinyl coating separated from the fabric and the adhesive.

Material No. 12

The fabric swelled during the first 2 weeks and then disintegrated. The hypalon turned brown and the seams had very little strength. Apparently, the seams failed because the hypalon became slimy. The Fairprene 5149 appeared to retain significant strength.

Material No. 14

The glass cloth did not show any visual deterioration, but it was much stiffer. The stiffness was probably due to the dissolved residues of other samples in the NH_4OH.

Material No. 18

The neoprene-nylon-neoprene did not show any deterioration due to the ammonia environment.

VI. CONCLUSIONS AND RECOMMENDATIONS

The only fabric which showed favorable life test characteristics was nylon. The only coating which withstood NH_3 and NH_4OH environments was neoprene. Neoprene owes its special stability to the fact that each chlorine atom is linked to a double bonded carbon. (A halogen atom directly attached to an ethylenic carbon atom displays definitely diminished reactivity.)

In the NH_3 - 100-percent relative humidity water environment, both neoprene adhesives (Caram 244 and Fairprene 5149) showed a significant retention of strength. In ammonium hydroxide, both showed significant deterioration after 8 weeks' immersion. The ammonium hydroxide represents a severe environment in that it contains free hydroxide ions which react with many organic functional groups.

The chemical composition of the Caram 244 and Fairprene 5149 is proprietary by their manufacturers. It is thought that neoprene rubber is their major component.

This preliminary effort indicates that future use of NH_3 as an inflatant is reasonable. The neoprene-coated nylon fabric showed no deterioration in either NH_3 gas or NH_4OH after 8 weeks. Future work is indicated in two areas:

1. Neoprene is not considered to have good weathering characteristics. Composites of neoprene-nylon fabric-weatherable coating should be evaluated with the neoprene side exposed to the NH_3 environment.
2. An extensive evaluation of neoprene-base and other rubber-base adhesives should be pursued. Methods of crosslinking these rubber-base adhesives would be desirable from the standpoint of minimizing NH_3 attack and minimizing creep in the seams.